change-ratio for rate of change of velocity or acceleration is $\frac{L}{T}$; and the change-ratio of any other physical quantity may be found by determining from its definition the manner in which its unit involves the fundamental units of mass, length and time. Now the theory of the change-ratios of electrical and magnetic quantities, in the electromagnetic system of units, shows that the change-ratio for resistance is the same as that for velocity; that in fact a resistance in electro-magnetic measure is expressible as a velocity; and hence we may with propriety speak of a resistance of one ohm as a velocity of 10^9 centimetres per second.

It is obvious from equation (14) that if V and R, each initially one unit, be increased in the same ratio, C will remain one unit of current; but that of V be, for example, 10^8 c.g.s. units of potential, or one volt, and R be a resistance of 10^9 cms. per second, or one ohm, C will be one-tenth of one c.g.s. unit of current. A current of this strength—that is, the current flowing in a wire of resistance one ohm, between the two ends of which a difference of potentials of one volt is maintained,—has been adopted as the practical unit of current and called one *ampere*. Hence it is to be remembered one ampere is one-tenth of one c.g.s. unit of current.

The amount of electricity conveyed in one second by a current of one ampere is called one *coulomb*. This unit although not quite so frequently required as the others, is very useful, as, for instance, for expressing the quantities of electricity which a secondary cell is capable of yielding in various circumstances. For example, in comparing different cells with one another their capacities, or the total quantities of electricity they are capable of yielding when fully charged, are very conveniently reckoned in coulombs per square centimetre of the area across which the electolytic action in each takes place.

The magneto-electric machine we have imagined gives us a very simple proof of the relation between the work done in maintaining a current, the strength of the current, and the electromotive force producing it. By the definitions given above of a magnetic pole and a magnetic field, a unit pole must produce at unit distance from itself a magnetic field of unit intensity. Again, unit current is defined as that current which flowing in a wire of unit length, bent into an arc of a circle of unit radius, acts on a unit magnetic pole at the centre of the circle with unit force. Hence, as the reaction of the pole on the current must be equal to the action of the current on the pole, this wire carrying the current is acted on by unit force tending to move it in the opposite direction to that in which the pole is moved, and it plainly does not matter which we suppose held fixed and which moved. Therefore a conductor in a magnetic field, and carrying a unit current which flows at right angles to the lines of force, is acted on by a force tending to move it in a direction at right angles to its length, and the magnitude of this force for unit length of conductor, and unit field, is by the definition of unit current equal to unity.

Applying this to our slider in which we may suppose a current of strength C to be kept flowing, say, from a battery in the circuit, let L be the length of the slider, v its velocity, and I the intensity of the field; we have for the force on the moving conductor the value ILC. Hence the rate at which work is done by the electromagnetic action between the current and the field is $ILC\frac{dx}{dt}$ or $ILCv$, and this must be equal to the rate at which work is done in generating by motion of the slider a current of strength C. But as we have seen above ILv is the electromotive force produced by the motion of the slider. Calling this now E, the symbol usually employed to denote electromotive force, we have EC as the rate of working, that is, the rate at which electrical energy is given out in the circuit.

By Ohm's law this value for the rate of working may be put into either of the two other forms, namely: $\frac{E^2}{R}$, or C^2R. In the latter of these forms the law was discovered by Joule, who measured the amount of heat generated in wires of different resistances by currents flowing through them. This law holds for every electric circuit whether of dynamo, battery, or thermoelectric arrangement.

We have, in what has gone before, supposed the slider to have no resistance comparable with the whole resistance in the circuit. If it has a resistance r, and R be the remainder of the resistance in circuit, the actual difference of potentials between its two ends will not be ILv or E, but $E\frac{R}{R+r}$. The rate per unit of time at which work is given out in the circuit is however still EC, of which the part $EC\frac{r}{R+r}$ is given out in the slider, and the remainder, $EC\frac{R}{R+r}$, in the remainder of the circuit. In short, if V be the actual difference of potentials, as measured by an electrometer, between two points in a metallic wire connecting the terminals of a battery or dynamo, and C be the current flowing in the wire, the rate at which energy is given out is VC, or if R be the resistance of the wire between the two points, C^2R.

One of the great advantages of the system of units of which I have given this brief sketch, is that it gives the value of the rate at which work is given out in the circuit, without its being necessary to introduce any coefficient such as would have been necessary if the units had been arbitrarily chosen. When the quantities are measured in c.g.s. units, the value of EC is given in terms of the centimeter-dyne or *erg*, the recognized dynamical unit of work. Results thus expressed may be reduced to *horse-power* by dividing by the number $7{\cdot}46\times10^9$; or if E is measured in volts, and C in amperes, EC may be reduced to horse-power by dividing by 746. Thus, if 90 volts be maintained between the terminals of a pair of incandescent lamps joined in series, and a current of 1·3 ampere flows through these lamps, the rate at which energy is given out in the lamps is approximately ·157 horse-power.

ANDREW GRAY

(*To be continued.*)

NATURAL SCIENCE IN THE OPEN COMPETITIVE EXAMINATIONS FOR CLERKSHIPS (CLASS I.) IN THE CIVIL SERVICE

THE Civil Service Commissioners have done much to encourage the thorough study of natural science in our Universities by the weight which they have assigned to it in the competitive examinations for first-class clerkships in the Government service. These posts are of sufficient value to attract young men of one or two-and-twenty, fresh from the University. It will be seen from the list of marks assigned to subjects, which we print below, that 1000 marks may be made in two branches of natural science, for instance, Zoology and Geology; whilst Greek and Roman language, literature, and history only stand for 1500. Hence a candidate who makes science his strong side and can do something in either English, classical, or foreign literary subjects, is by no means at a disadvantage.

We take this opportunity of prominently drawing attention to the encouragement thus given to the pursuit of natural science as a branch of culture.

The schoolboy who is excused from verse-composition and sent into the chemical laboratory, is distinctly recognised, and has a fair chance given to him by the Commissioners. So too the Oxford undergraduate who breaks with the wearisome iteration of Greek play and Latin

odes in the College lecture-room and escapes to the fascinating microscopes and dissecting troughs of Prof. Moseley, or the verniers and milligram-weighing pans of Prof. Clifton, is marked out for patronage. And not only indeed are Oxford and Cambridge students of science thus benefited.

The courses of instruction in scientific subjects given at the London Colleges, University and King's, are pre-eminently such as will enable a candidate to do justice to his abilities in this examination. The examination is practical, and no mere smattering of a subject will obtain any marks for a candidate. Hence the "crammers" are at a disadvantage, and the teachers in duly-organised and properly-furnished laboratories, are rightly encouraged in their efforts to carry on thorough courses of instruction. It is indeed, a matter for satisfaction that hitherto the various cramming establishments where young men are "prepared" for public examinations have failed to enable any candidate to gain a success in any branch of natural science in these higher competitive examinations, those candidates who have scored marks in natural science having been University students. We subjoin an extract from the Regulations issued by the Civil Service Commission, to the secretary of which body application for further information should be made.

1. The limits of age for these situations are 18 and 24, and candidates must be of the prescribed age on the first day of the competitive examination.

2. At the competitive examinations exercises will be set in the following subjects only; the maximum of marks for each subject being fixed as follows, viz. :—

	Marks.
English Composition (including Précis-writing)... ...	500
History of England—including that of the Laws and Constitution...	500
English Language and Literature	500
Language, Literature, and History of Greece	750
,, ,, ,, Rome	750
,, ,, ,, France	375
,, ,, ,, Germany ...	375
,, ,, ,, Italy	375
Mathematics (pure and mixed)	1250
Natural Science: that is, (1) Chemistry, including Heat; (2) Electricity and Magnetism; (3) Geology and Mineralogy; (4) Zoology; (5) Botany	1000
*** The total (1000) marks may be obtained by adequate proficiency in any two or more of the five branches of science included under this head.	
Moral Sciences: that is, Logic, Mental and Moral Philosophy	500
Jurisprudence	375
Political Economy	375

Candidates will be at liberty to offer themselves for examination in any or all of these subjects. No subjects are obligatory.

No candidate will be allowed any marks in respect of any subject of examination unless he shall be considered to possess a *competent knowledge* of that subject.

NOTES

A TELEGRAM, dated December 21, has been received by the Finnish Academy of Sciences from Prof. S. Lemström, chief of the Finnish Meteorological Observatory at Sodankylä. He states that, having placed a galvanic battery with conductors covering an area of 900 square metres on the hill of Oratunturi, he found the cone to be generally surrounded by a halo, yellow-white in colour, which faintly but perfectly yields the spectrum of the aurora borealis. This, he states, furnishes a direct proof of the electrical nature of the aurora, and opens a new field in the study of the physical condition of the earth. A further telegram, dated Sodankylä, January 5, has been received, in which Prof. Lemström states that experiments with the aurora borealis made December 29, in Enare, near Kultala, on the hill of Pietarintunturi, confirm the results of those at Oratunturi. On that date a straight beam of aurora was seen over the galvanic apparatus. It also appears from the magnetic observations that the terrestrial current ceases below the aurora arc, while the atmospheric current rapidly increases, but depends on the area of the galvanic apparatus to which it seems to be proportional. The Professor regrets that with the means at his disposal further experiments cannot be made, and that he intended, on the 13th inst., to withdraw the apparatus.

THE Report of the Royal Gardens, Kew, for 1881, shows what a large amount of varied and highly useful work is got through in the space of a year at that great national establishment; perhaps *imperial* would be more accurate than national, for it is really the botanical and horticultural centre of the whole empire. One important feature is the lessons given during the year to the young gardeners in the science of these subjects; this will certainly tend to secure that the work of the gardens throughout are conducted with intelligence and on a sound scientific basis. The Report contains extracts from the reports of various Colonial curators, on the progress of experiment in the culture of certain important plants, such as Cinchona and india-rubber. Mr. Jamieson reports from the Nilgiris that he has found the Cape Coast and Liberian coffee-plants to be really two varieties. Queensland may yet add coffee to its other industries, a vastly important addition. The Report contains an illustration of *Cinchona Ledgeriana*, Moens.

IN preparation for the International Fisheries Exhibition there is a large number of artificers now employed in erecting and completing enormous buildings for the reception of the exhibits on the ground known as the Royal Horticultural Gardens, South Kensington. Some four or five immense structures have been already erected, two standing side by side on the western side of the gardens—one being about 180 yards, the other some 140 yards in length, with a width of about 20 yards, and of great height and capacity. Arched roofs contain in the centre, running the whole length of the building, a wide breadth of glass, which throws below as ample an amount of light as can be desired. Other similar buildings are in the course of completion at the north-eastern corner of the gardens, close to the Albert Hall; and when the capacity of all these structures is considered, some estimate can be formed of the enormous proportions the International Exhibition will assume. The arcade at the south-western side of the gardens, well known for the horticultural and other expositions which the Royal Horticultural Society has held in it, is being devoted to the purposes of an aquarium, which will soon be completed, and in which both fre h-water and sea fish will be exhibited. The spacious long arcade affords ample room for all the tanks that may be required, and it is expected that the aquarium will form one of the most attractive features of the exhibition. Arrangements will be made to provide easy access from one building to another, and such portions of the gardens as remain uncovered by the necessary structures will serve as an agreeable promenade. All the works are so forward that everything will be ready in good time for the reception of the exhibits of our own and of foreign countries.

CONSIDERABLE success has attended the Sunday Evening Association, its object being to bring together all persons who, estimating highly the elevating influence of music, the sister arts, literature and science, desire, by means of meetings on Sunday evenings, to see them more fully identified with the religious life of the people. The president is Dr. Geo. J. Romanes, F.R.S. The fifth series of meetings will be concluded next Sunday with a lecture by Dr. W. B. Carpenter, F.R.S., C.B., on "Niagara." A sixth series will be commenced on Sunday, February 11, and will include lectures by Dr. G. J. Romanes, F.R.S., on "Star